Today’s homework is homework #3, due 11pm, Wednesday, June 15!!
Announcements

• Reading assignments
  – CH22.4
Reminder: Special Project #2 – Angels & Demons

• Compute the total possible energy released from an annihilation of x-grams of anti-matter and the same quantity of matter, where x is the last two digits of your SS#. (20 points)
  – Use the famous Einstein’s formula for mass-energy equivalence

• Compute the power output of this annihilation when the energy is released in x ns, where x is again the first two digits of your SS#. (10 points)

• Compute how many cups of gasoline (8MJ) this energy corresponds to. (5 points)

• Compute how many months of world electricity usage (3.6GJ/mo) this energy corresponds to. (5 points)

• Due by the beginning of the class Thursday, June 16.
Special Project

- **Particle Accelerator.** A charged particle of mass $M$ with charge $-Q$ is accelerated in the uniform field $E$ between two parallel charged plates whose separation is $D$ as shown in the figure on the right. The charged particle is accelerated from an initial speed $v_0$ near the negative plate and passes through a tiny hole in the positive plate.

  - Derive the formula for the electric field $E$ to accelerate the charged particle to a fraction $f$ of the speed of light $c$. Express $E$ in terms of $M$, $Q$, $D$, $f$, $c$ and $v_0$.
  - (a) Using the Coulomb force and kinematic equations. (8 points)
  - (b) Using the work-kinetic energy theorem. (8 points)
  - (c) Using the formula above, evaluate the strength of the electric field $E$ to accelerate an electron from 0.1% of the speed of light to 90% of the speed of light. You need to look up the relevant constants, such as mass of the electron, charge of the electron and the speed of light. (5 points)

- Due beginning of the class Monday, June 20
Gauss’ Law

• Gauss’ law states the relationship between electric charge and the electric field.
  – More generalized and elegant form of Coulomb’s law.

• The electric field by the distribution of charges can be obtained using Coulomb’s law by summing (or integrating) over the charge distributions.

• Gauss’ law, however, gives an additional insight into the nature of electrostatic field and a more general relationship between the charge and the field
Let’s imagine a surface of area $A$ through which a uniform electric field $E$ passes.

The electric flux $\Phi_E$ is defined as:
- $\Phi_E = E A$, if the field is perpendicular to the surface.
- $\Phi_E = E A \cos \theta$, if the field makes an angle $\theta$ to the surface.

So the electric flux is defined as $\Phi_E = \vec{E} \cdot \vec{A}$.

How would you define the electric flux in words?
- The total number of field lines passing through the unit area perpendicular to the field.

$N_E \propto E A_{\perp} = \Phi_E$
Example 22 – 1

• Electric flux. (a) Calculate the electric flux through the rectangle in the figure (a). The rectangle is 10cm by 20cm and the electric field is uniform with magnitude 200N/C. (b) What is the flux in figure if the angle is 30 degrees?

The electric flux is defined as

\[ \Phi_E = \vec{E} \cdot \vec{A} = EA \cos \theta \]

So when (a) \( \theta=0 \), we obtain

\[ \Phi_E = EA \cos \theta = EA = (200 \text{N/C}) \cdot (0.1 \times 0.2 \text{m}^2) = 4.0 \text{N} \cdot \text{m}^2/\text{C} \]

And when (b) \( \theta=30 \) degrees, we obtain

\[ \Phi_E = EA \cos 30^\circ = (200 \text{N/C}) \cdot (0.1 \times 0.2 \text{m}^2) \cos 30^\circ = 3.5 \text{N} \cdot \text{m}^2/\text{C} \]